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(56) Documents Cited by ISA:
US 6003605 A
US 3958633 A
US 2780290 A
US 4422618 A
US 2798561 A

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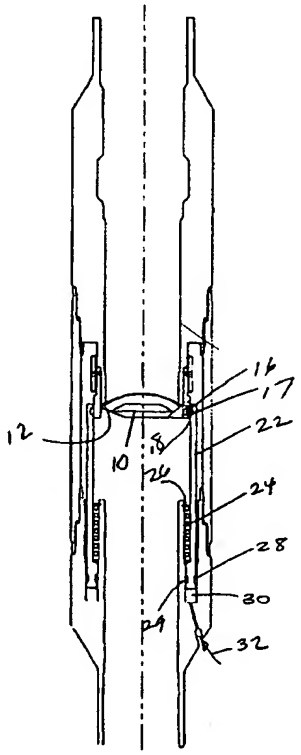
(54) Abstract Title: **Closure mechanism with integrated actuator for subsurface valves**

(57) A subsurface safety valve has a closure sleeve (122) or rod (38) mounted below the closure mechanism. Control signal pushes the sleeve up (uphole) or down (downhole), whichever is applicable, which causes the closure element (10) to rotate (or slide, or otherwise translate) to its open position. A loss of control signal allows the closure spring (24) to push the sleeve or rod downhole (or uphole, whichever is appropriate). This movement causes the closure element to be driven to its closed position against the seat.



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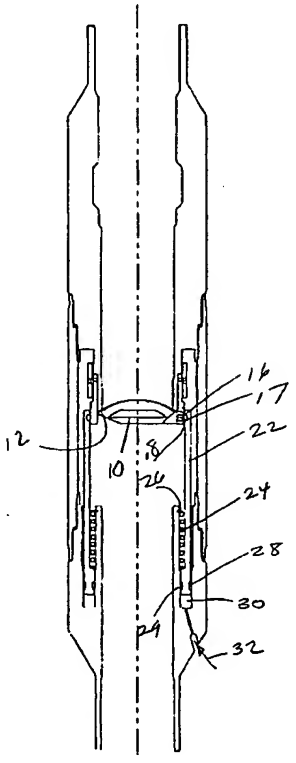
(54) Title: CLOSURE MECHANISM WITH INTEGRATED ACTUATOR FOR SUBSURFACE VALVES

(57) Abstract: A subsurface safety valve has a closure sleeve (122) or rod (38) mounted below the closure mechanism. Control signal pushes the sleeve up (uphole) or down (downhole), whichever is applicable, which causes the closure element (10) to rotate (or slide, or otherwise translate) to its open position. A loss of control signal allows the closure spring (24) to push the sleeve or rod downhole (or uphole, whichever is appropriate). This movement causes the closure element to be driven to its closed position against the seat.



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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

APPLICATION FOR PATENT

Inventors: Douglas Trott, Brian Shaw and David McMahon

Title: Closure Mechanism with Integrated Actuator for Subsurface Valves

PRIORITY INFORMATION

[0001] This application claims the benefit of U.S. Provisional Application No. 60/334,321 filed on November 30, 2001.

FIELD OF THE INVENTION

[0002] The field of this invention is surface controlled subsurface safety valves and more particularly actuating mechanisms for the closure element.

BACKGROUND OF THE INVENTION

[0003] Traditionally, sub-surface safety valves (SSSV) have had a flat or curved closure element known as a flapper, or a ball-shaped closure element, which rotates approximately 90 degrees, from opened to closed positions, under the bias of a closure spring generally mounted to the hinge holding the closure element to the valve body. The closure spring acts on the closure element after a flow tube or other actuating element is retracted. The flow tube and actuator mechanism are typically mounted above the closure element and inside the seat against which the closure element contacts for closure. The flow tube and actuator are biased in the uphole (closed) direction by a separate spring, commonly known as the power spring, and are driven down against the spring bias and into the closure element by pressure (or other appropriate signal) delivered through a control line extending to the SSSV from the surface. As long as control line pressure (or other appropriate signal) is applied to the actuator the power spring bias on the flow tube is overcome and the flow tube stays in a down (open) position. In the down position of the flow tube, the closure element is rotated against the bias of the closure spring, and away from contact with the mating seat. The closure element winds up behind or adjacent to the flow tube when the SSSV is open. If control line pressure (or signal) is lost, the

power spring bias on the flow tube pushes it and the actuator mechanism uphole. This movement, in turn, allows the closure spring, acting on the closure element, to rotate the closure element on its hinge in an uphole direction until it makes contact with the mating seat.

[0004] Traditionally, the flow tube and the actuator mechanism have always been above the closure element. This required the bias (power) spring on the flow tube to support the weight and overcome friction of the flow tube as well as to bias it uphole to allow the closure element to shut. Since the flapper had to rotate 90 degrees in the uphole direction to close the SSSV, a hinge closure spring was always necessary to create that motion to overcome the weight of the flapper and apply a contact force to it to hold it against its mating seat. As a result of this configuration, the overall length of SSSVs was longer than it needed to be. In low pressure applications, there was concern about the ability of the closure spring on the flapper to apply a sufficient closing force against the mating seat to keep the SSSV closed. This concern also arose when there was sand, paraffin, asphaltine or other friction increasing compounds in the well fluids, creating doubt as to the available closure force on the flow tube from its power spring. If the flow tube gets stuck, the SSSV cannot close.

[0005] The present invention presents a unique design where the actuator mechanism is below the flapper. The power spring acts on a sleeve or rod operably connected to the flapper on an opposed side of the pivot mounting. The spring pushes the sleeve or rod downhole to rotate the flapper closed, upon loss of control line signal. The details and other features of the invention will become more readily apparent from a detailed review of the description of the preferred embodiment, which appears below.

SUMMARY OF THE INVENTION

[0006] A subsurface safety valve has a closure sleeve or rod mounted below the closure mechanism. Control signal pushes the sleeve up (uphole) or down (downhole), whichever is applicable, which causes the closure element to rotate (or slide, or otherwise translate) to its open position. A loss of control signal allows the closure spring to push

the sleeve or rod downhole (or uphole, whichever is appropriate). This movement causes the closure element to be driven to its closed position against the seat.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a sectional elevation view of the safety valve of the present invention in the closed position using an annular sleeve to actuate the flapper

[0008] Figure 2 is an alternative to Fig. 1 using a rod piston to actuate the flapper;

[0009] Figure 3 is a section view of a rack and pinion assembly for operating the flapper

[0010] Figure 4 is an alternative to Fig. 1 illustrating an actuator which moves in the opposite direction as that of Fig. 1, yet accomplishes the same task – moving the closure element to the closed position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Referring to Fig. 1, the flapper 10 is shown in the closed position against a seat 12 located in body 14 of the SSV. The flapper 10 is connected to body 14 at pin 16 and hinge 17. Extending away from the sealing portion of the flapper 10 in contact with the seat 12 is an arm 18. Arm 18 extends into a groove 20 in annular piston 22. Spring 24 acting against stop 26 biases annular piston 22 downwardly. Seals 28 and 29 define a variable volume annular cavity 30. Arrow 32 shows schematically how the control line communicates hydraulic pressure (signal) from the well surface to overcome the downward bias of spring 24. Those skilled in the art will appreciate that the signal can be surface or downhole generated and can take various forms. The control system can involve electro-hydraulic (patent number 6,269,874), electro-mechanical (patent number 6,253,843), and photo-hydraulic techniques. When enough pressure is applied or some other signal is transmitted such as electro-mechanical, acoustic, or electromagnetic, for example, the annular piston moves up and rotates arm 18 about pin 16 to rotate the flapper 10 away from seat 12. If pressure or other signal is removed or lost in the control line represented by arrow 32 or due to leakage of seal 28 or for other reasons, the spring

24 will push the annular piston downhole. Groove 20 will rotate arm 18 clockwise to forcibly bring the flapper 10 into contact with the seat 12.

[0012] The arm 18 extending into the groove 20 can be replaced with a rack and pinion design, as shown in Fig. 3. Annular piston 22' has teeth 34 which extend into contact with pinion 36. Pinion 36 is attached or made integral with the flapper 10. In each instance movement of the annular piston 22 or 22' in opposed directions results in a desired 90 degree rotational movement of the flapper 10. The torsion spring for flapper closure in prior designs has been eliminated. In this design there is only one spring 24. Due to the orientation of the annular piston 22 below the flapper 10, the weight of the annular piston 22 adds to the closure force of spring 24 on flapper 10. Additionally using arm 18 extending into groove 20 or the rack and pinion connection shown in Fig. 3, the stroke length of the annular piston 22 is significantly reduced as compared to prior designs having a flow tube and actuator above the flapper. In the prior designs, the stroke length had to be longer to get the flow tube down far enough so that the entire flapper would be disposed behind it. For a similar size SSV the overall length of the present design could be significantly shorter since the stroke length has been reduced from several inches for a traditional flow tube to less than an inch for the versions of the present invention shown in Figs. 1 and 3.

[0013] Figure 2 is a schematic illustration showing the use of a rod piston 38 instead of the annular piston 22 shown in Fig. 1. The part positions and operation are otherwise the same as described for the Fig. 1 embodiment. The rod piston 38 can have a slot 40 into which arm 18' is engaged for forced movement of the flapper 10' in opposed directions. A rack and pinion design, as described above, can also be employed.

[0014] Those skilled in the art will appreciate that the present invention allows SSVs to be made shorter and more economically. Fewer moving parts also imply increased reliability. The torsion spring, the flow tube, and the components linking the piston to the flow tube are eliminated. A single spring forcibly moves the flapper and the piston to the closed position. The closure spring 24 does not have to support the weight of the piston 22 or 38 when moving the flapper 10 to its closed position. Control line

pressure or other signal moves the piston **22** or **38**, either of which is linked directly to the flapper for application of a moment to rotate it to the open position. Those skilled in the art will appreciate that a variety of connections can be used between a piston mounted below the flapper and the flapper, as being contemplated by the invention. While direct contact, such as arm **32** extending into groove **20** is preferred, indirect contact is also envisioned. For example, an arrangement of components can be envisioned such that the piston is urged in the opposite direction as that described above. In this case, indirect contact between the arm (or sleeve) and the closure element may be appropriate.

[0015] Those skilled in the art will appreciate that the closure element can be a flapper, a ball, a sliding gate or any other device that effects closure. Reference to one type of closure element is intended to encompass any of the known alternative designs. The actuator can be linked to the closure member directly such as when the rack and pinion mechanism illustrated in Figure 3 is employed. The actuator can be linked to the closure member indirectly such as when the actuator is configured to move uphole to close the closure element, as shown in Figure 4. The disclosed embodiments allow the safety valve to be shorter in overall length and have fewer moving parts than prior designs, thus offering greater reliability. Another advantage is that a single biasing source, such as a closure spring operates both the actuator and the closure element.

[0016] The full extent of the invention is delineated in the claims below.

We claim:

1. A downhole safety valve, comprising:

a housing having uphole and downhole ends;

a closure element mounted to said housing; and

an actuator to move said closure element, said actuator mounted substantially between said closure element and said downhole end of said housing.

2. The safety valve of claim 1, wherein:

said actuator forcibly pivots said closure element selectively in opposed directions.

3. The safety valve of claim 1, wherein:

said closure element pivots between an open and a closed position; and

the weight of said actuator provides at least part of the force to urge said closure element to said closed position.

4. The safety valve of claim 1, wherein:

said actuator is connected directly to said closure element.

5. The safety valve of claim 4, wherein:

said closure element comprises a hinge extending beyond a mounting pin supported by said housing;

said actuator is connected to said extending hinge portion beyond said mounting pin.

6. The safety valve of claim 5, wherein:

said connection between said actuator and said hinge portion is accomplished by meshing gears.

7. The safety valve of claim 5, wherein:

said connection between said actuator and said hinge portion is accomplished by a projection on one engaging a depression in the other.

8. The safety valve of claim 5, wherein:

said actuator comprises an annular piston mounted in said housing.

9. The safety valve of claim 5, wherein:

said actuator comprises a rod piston mounted in said housing.

10. The safety valve of claim 5, wherein:

said closure element pivots between an open and a closed position; and

said actuator is biased to urge said closure element toward said closed position.

11. The safety valve of claim 10, wherein:

said actuator defines a variable volume cavity in said body, said cavity having an inlet on the housing to facilitate movement of said actuator against said bias.

12. The safety valve of claim 11, wherein:

said inlet is located between said closure element and said downhole end of said housing.

13. The safety valve of claim 11, wherein:

said actuator forcibly pivots said closure element selectively in opposed directions.

14. The safety valve of claim 13, wherein:

the weight of said actuator provides at least part of the force to urge said closure element to said closed position.

15. The safety valve of claim 14, wherein:

said connection between said actuator and said hinge portion is accomplished by meshing gears.

16. The safety valve of claim 14, wherein:

said connection between said actuator and said hinge portion is accomplished by a projection on one engaging a depression in the other.

17. The safety valve of claim 15, wherein:

said actuator comprises an annular piston mounted in said housing.

18. The safety valve of claim 15, wherein:

said actuator comprises a rod piston mounted in said housing.

19. The safety valve of claim 16, wherein:

said actuator comprises an annular piston mounted in said housing.

20. The safety valve of claim 16, wherein:

said actuator comprises a rod piston mounted in said housing.

21. The safety valve of claim 1, wherein:

said actuator is connected indirectly to said closure element.

22. The safety valve of claim 21, wherein:

said actuator moves toward said uphole end to move said closure element to a closed position.

23. The safety valve of claim 1, wherein:

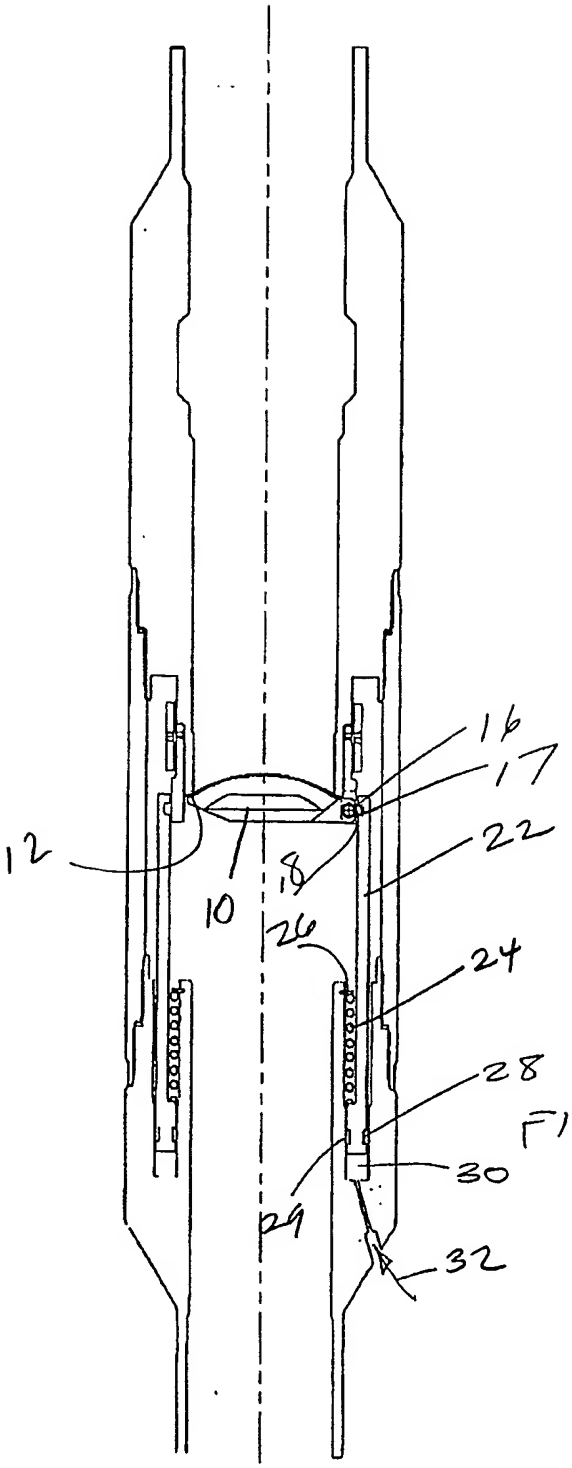
said actuator moves toward said downhole end to move said closure element to a closed position.

24. The safety valve of claim 1, wherein:

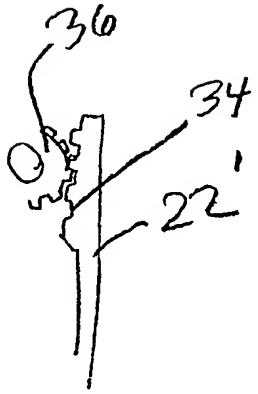
said closure element comprises one of a flapper, a ball and a sliding gate.

25. The safety valve of claim 1, wherein:

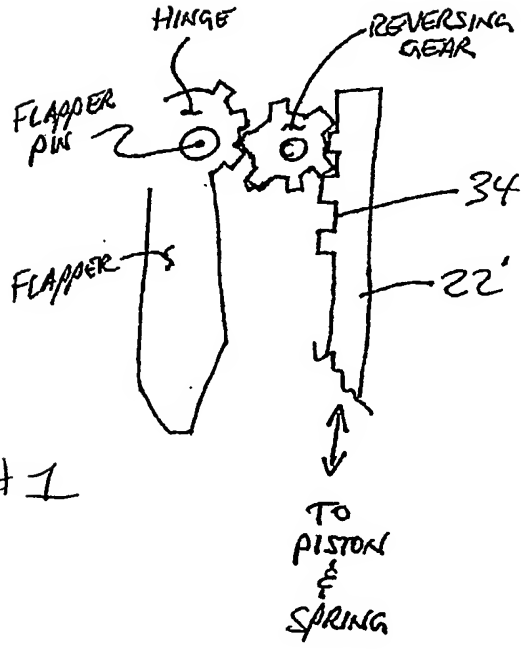
said actuator and said closure element are urged toward said closed position by a single biasing element.



FIG#1



FIG#3



FIG#4

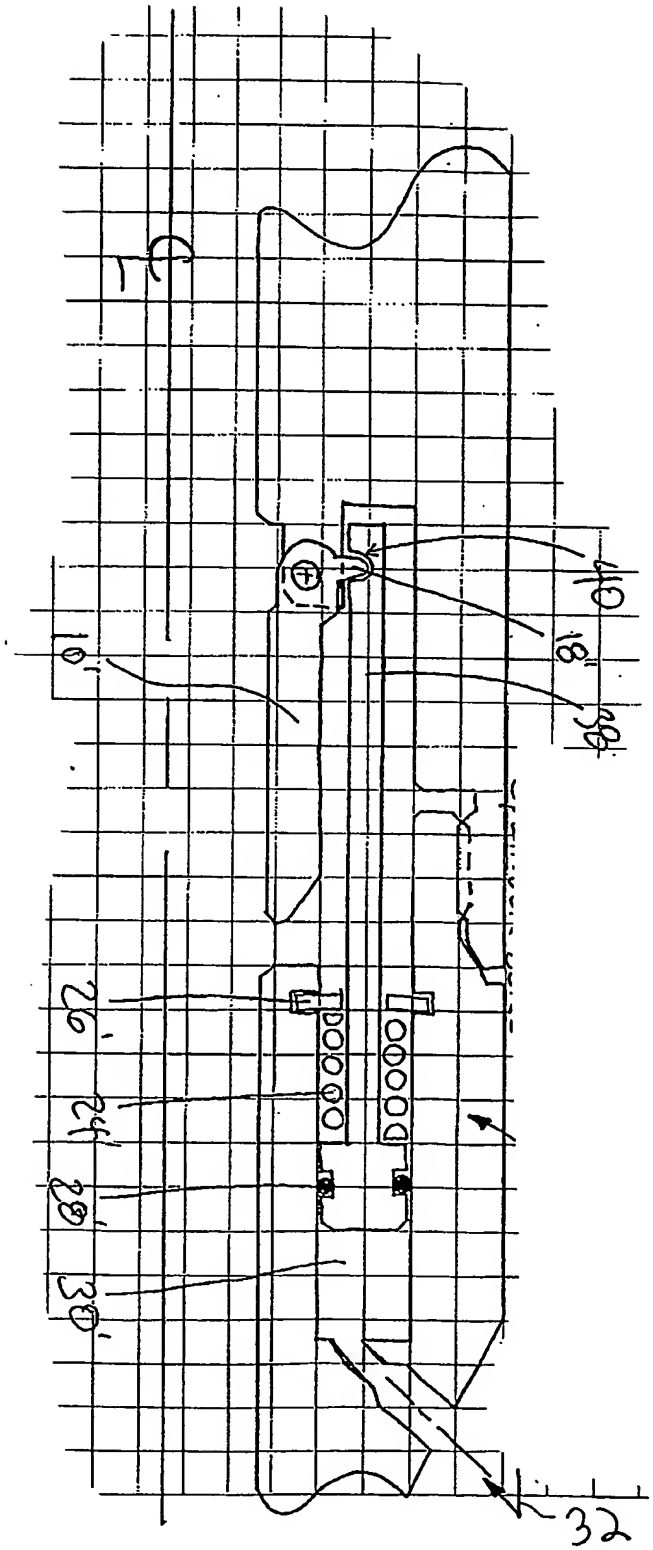


Fig 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/37783

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B34/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 798 561 A (TRUE MARTIN E) 9 July 1957 (1957-07-09) column 2, line 19 - line 51; figures 1,3	1-7, 9-16,18, 20,23
X	US 4 422 618 A (LAWSON JOHN E) 27 December 1983 (1983-12-27) abstract; figures 1,8	1-3,21, 22
X	US 3 958 633 A (BRITCH JAMES A ET AL) 25 May 1976 (1976-05-25) the whole document	1-4,23
X	US 2 780 290 A (NATHO PAUL J) 5 February 1957 (1957-02-05) the whole document	1-3,21, 23

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
11 March 2003	21/03/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Ott, S

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INTERNATIONAL SEARCH REPORT

Intern[illegible]al Application No
PCT/US 02/37783

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 003 605 A (LE NAM VAN ET AL) 21 December 1999 (1999-12-21) the whole document	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 02/37783

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2798561	A	09-07-1957	NONE	
US 4422618	A	27-12-1983	NONE	
US 3958633	A	25-05-1976	NONE	
US 2780290	A	05-02-1957	NONE	
US 6003605	A	21-12-1999	NONE	